3. The Tape-Worms (*Cestoda*) of the Red Grouse (*Lagopus scoticus*).

By A. E. Shipley, M.A., Hon.D.Sc., F.R.S., F.Z.S., Fellow and Tutor of Christ's College, Cambridge, and Reader in Zoology in the University. With a Note by Wm. Bygrave, M.A.

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(Plates LVI.–LX.*)

CESTODA.

Three species of tape-worm live in the alimentary canal of the Grouse. The largest of these is (i.) *Davainea urogalli* (Modeer), which lives in the small intestine (Pl. LVII. fig. 2). We have also from time to time found it in the cæca; its presence there is probably due to post-mortem migrations. This is the tape-worm known to the keepers and to sportsmen generally. It is large, sometimes a foot or more in length, and is occasionally seen protruding from the bird's anus and trailing through the air as the bird flies. The second and third tape-worms are inconspicuous and have hitherto escaped notice. One of them, (ii.) *Davainea cesticillus* (Molin), is small and very rare, we have only found it twice in the many hundreds of Grouse we have examined. It occurs, a few at a time, in the small intestine. The third tape-worm, (iii.) *Hymenolepis microps* (Diesing), is also inconspicuous, and so transparent when alive as almost to be invisible. It exists in hundreds in the duodenum, and probably causes a considerable amount of disease and death to the birds (Pl. LVII. fig. 4). It is by far the most dangerous of the three tape-worms of the Grouse.

(i.) Fam. Tæniidæ.

Genus Davainea R. Bl. & Raill., 1891.

(i.) Davainea urogalli (Modeer), 1790.

Synonyms: *Tænia urogalli* Modeer, 1790.
Tænia calva Baird, 1853.
Davainea calva Shipley, 1906.

The worm was apparently named *Tænia urogalli* by Modeer † in the year 1790. I am greatly indebted to Dr. O. Fuhrmann, of Neuchâtel, for pointing out that this tape-worm is identical with that described in 1853 by Baird and called by him *Tænia calva*.

The following is Baird's ‡ description :—

"*Tænia calva* Baird, Cat. Entoz. Brit. Mus. 83.

"Head small, rounded and smooth, white and shining. Mouth unarmed. Neck constricted. Articulations of body at first very

* For explanation of the Plates see p. 362.
† Vet. Ac. Nya Handl. 1790, p. 129.
‡ Proc. Zool. Soc. Lond. xxi. 1853, p. 24.

small, gradually enlarging in breadth as they descend till they reach about the middle of the body, where they are still narrow, linear-shaped, and about seven times broader than long. After this they begin to increase in length and diminish in breadth, becoming at first nearly square, and at last, near the extremity, nearly twice as long as broad. All the articulations are strongly striated across, and the upper and lower margins, where they join with each other, are considerably thickened. Length $5\frac{1}{2}$ inches, greatest breadth $3\frac{1}{2}$ lines, breadth of lower extremity 1 millimetre, of head $\frac{1}{6}$ mm.

"*Hab.* Intestines of the common Grouse, *Lagopus scoticus*, Brit. Mus."

The same worm has been more fully described, also under the name *T. calva*, by F. S. Monticelli *.

The genus *Tænia* has been comparatively lately broken up into a number of other genera, and one genus *Davainea*, named after the celebrated French helminthologist Davaine, has been established for those worms which have the rostellum and suckers armed with a multitude of characteristically shaped hooks or thorns. The genus was made in 1891 by R. Blanchard and A. Railliet, and it comprises a number of species which, as a rule, live in the small intestines of birds.

Specimens of *Davainea urogalli* vary greatly in appearance and in size. On the whole, they have in life rather an untidy, dishevelled appearance, without clear-cut features; some preserved specimens, however, had very definite outlines. Doubtless much depended on the preservative.

Our longest specimens measured 35 cm. in length; the greatest breadth was 4 mm. The preserved material evidently died in very varying states of contraction, and it is difficult to make general statements as to the relative proportions of different parts of the body. One specimen 35 cm. in length we found in a bird of not more than three weeks old. It was shedding ripe proglottides. This worm had split and presented a forked tail, one limb of which, however, seemed to have dwindled and come to nothing.

The head is very small. Baird gives its breadth as "$\frac{1}{6}$ mm." I should put it at about the same, but here, as elsewhere, no two specimens are exactly alike. The proglottides which follow are extremely narrow from behind forward, but they very rapidly increase in breadth, so that 6 or 7 mm. from the head the breadth is 1 mm., and at about 12 to 15 mm. it is 2 mm. The greatest breadth is usually about 2·5 mm. to 3 mm., but in some specimens 4 mm. are reached (Pl. LVII. fig. 2). The broadest portion is usually about the third quarter of the body from the head; even here the segments still have but a very shallow antero-posterior diameter, about 0·6 mm. to 1 mm. Behind this region the segments narrow again. They become as long as they are broad,

* Boll. Soc. Napoli, ser. I. v. 1891, p. 155.

and but for the prominent posterior lip the segments would be square. The posterior segments are, however, longer than they are broad, and quite at the hinder end they are attached to one another by but a slender connection. The prominent posterior angle is maintained to the last. It is, however, difficult to give precise statements as to the condition of this worm. In some, one region of the body will be swollen out; in other specimens, other regions will expand. Some have a thin, papery consistence; others are plump and almost circular in section. Sometimes the posterior rim overlaps the anterior region of the succeeding segment, so that the whole resembles the pile of conical caps which clowns used—I do not know whether they still do so—to wear in the circus. These varying conditions doubtless depend largely on the state of the parasite when killed and on the means taken to kill them. The genital pore is, except in rare cases, on one and the same side.

The anterior end tapers quickly to the very small, squarish head (Pls. LVI. & LIX. figs. 2 & 6). Anteriorly, the head ends in a rostellum, which seems nearly always to be retracted into a shallow recess. At each of its four corners the head bears a large sucker, as a rule circular, but at times oval in shape, and then the long axis is longitudinal.

Both rostellum and suckers bear hooks, which differ, however, both in their arrangement and shape. The hooks of the rostellum are arranged in a double row. Each is shaped something between a Y and a T (Pl. LIX. figs. 7 & 8), one arm being more curved than the other and it is this arm which is anterior. The stalk of the hook is but very slightly curved, and the posterior row alternates with the anterior. The length of the hooks is between 6·9 μ and 6·6 μ. The shape of the hooks does not vary appreciably and the arrangement in two rings is very regular. These hooks were not seen by Baird and were first recognised in 1891 *.

The hooks on the suckers are also very minute, and they vary considerably in size: the largest forms are about as long as the rostellar hooks, *i. e.* 6·6 μ; the smallest forms are perhaps half this size, and there are intermediate sizes. Each hook is slightly curved and tapers to a fine point, each possesses a "heel" which, as is shown in fig. 10, Pl. LIX., is developed in varying degrees. In many cases the proximal end resembles the "head" of a thigh-bone. The hooks are arranged in a ring, but the ring contains no definite and regularly arranged rows, rather it is a small circular forest or hedge of hooks of varying sizes and shapes (Pl. LIX. fig. 9).

The head is usually followed by an unsegmented neck, three or four millimetres in length, but I have seen one or two specimens in which the segmentation occurs immediately behind the head. In transparent specimens longitudinal muscles running to the suckers can be seen traversing the neck. In most specimens the

* F. S. Monticelli, Boll. Soc. Napoli, ser. I. v. 1891, p. 155.

reproductive pore is on one side of the body throughout its entire length, but in others, and rarer, it changes over and having been for the anterior half of the body on the right side it suddenly passes to the left and remains there till the end.

The number of the proglottides varies with the length of the worm. An average-sized specimen would have between 250 and 400 proglottides; each of these might contain, say, a couple of hundred eggs. These figures, though necessarily rough, give some idea of the number of ova a single tape-worm may contain at any one moment. But mature proglottides are always breaking away and fresh ones are always being formed, like a recurring decimal, so that the number of ova a tape-worm produces in the course of its life is very much greater than the number it contains at any one moment.

Although the male and female reproductive openings are close together, the male orifice is very clearly anterior to that of the female. It leads into a muscular protrusible penis, which was in all cases retracted. The penis ends in a much coiled vas deferens which runs half across the proglottis near and slightly obliquely to the anterior edge; here it ends in a number of diverticula which form the testes. These are scattered through the parenchyma. The wall of the vas deferens is thin, its lumen is spacious, and it acts as a vesicula seminalis. The lumen is lined by a thin cuticle, and outside this and all around it are a number of spherical or oval cells which without exactly forming an epithelium probably secrete the cuticle.

The vagina opens immediately behind the vas deferens. Its outermost part is thick-walled and the lumen contains some homogeneous substance which stains deeply; further on the wall becomes thinner, the lumen more capacious, and here masses of spermatozoa are to be seen. The ovaries are two, right and left, each rather of a cauliflower shape; they contain rounded ova in which besides the nucleus a second deeply staining body is sometimes seen. The vagina makes a turn through about a right angle, and passing between the two ovaries, where it receives the two oviducts, it travels back to the vitellarium, a somewhat pyramidal body lying close to the posterior end of each proglottis. Certain unicellular glands in this region of the female duct are probably shell-glands.

There seems to be no walled uterus, but the fertilized ova are scattered throughout the body embedded in the parenchyma. Each is a large oval cell with very vacuolated protoplasm and a nucleus at one side and numerous yolk-granules (Pl. LIX. fig. 12).

Monticelli describes the proglottides as longitudinally striated, and the striations as due to the longitudinal muscles. These are certainly conspicuous in section, although in our specimens the external striation was not very well marked.

One striking feature of *D. urogalli* is the great extent to which the water vascular system is developed. It is spacious and large in the anterior segments, but in the posterior half of the body it

becomes very much larger. The lumen of the lateral canals increases and the transverse duct which unites them at the posterior end of each proglottis swells out amazingly. From being a slender duct it enlarges to a great spherical chamber, of which the sides, which will rupture when the proglottis drops off, are extremely thin (Pl. LIX. fig. 13 & Pl. LX. fig. 14).

When the ova are squeezed out of a living ripe proglottis of *D. urogalli*, they present the appearance shown in Pl. LIX. fig. 12. A more highly magnified view is shown in Pl. LX. fig. 15. Each egg contains a six-hooked embryo which is much smaller than the egg-shell. Besides the six-hooked embryo, the egg-shell contains two or three spherical bodies usually of about the same diameter as the embryo, but sometimes smaller. These are apparently yolk-spheres in course of absorption; the remainder of the egg-shell is empty. The six hooks, arranged in three pairs, have a characteristic shape shown best in Pl. LX. fig. 16. The shape is similar to that of the hooks figured in the sketches of *Davainea* embryos in Blanchard's article *.

The genus *Davainea* occurs in many birds, Cursores, Gallinaceæ, Columbinæ, &c., and much more rarely, in the form of *Davainea madagascariensis* (Dav.), in the intestine of man. Little is known of their second hosts; they are usually believed to be insect larvæ, centipedes, or land mollusks. Grassi and Rovelli † consider the intermediate host of the *D. proglottina* of the common fowl to be *Limax cinereus*, *L. agrestis*, and *L. variegatus*. In this case the cysticercoid is fully developed in the slug within twenty days. If the slug be swallowed by a fowl the cysticercoid becomes adult at the end of eight days. We have up till now sought for the cystic form in *Limax flavus* without success.

Davainea echinohothrida ‡, which is possibly a synonym of *D. tetragona*, causes a nodular disease in poultry §, a condition liable to be mistaken for tuberculosis. This disease was first recorded in the United States by Moore (1895) ‖, from whose article the following extracts are made:—

"The nodules were invariably more numerous in the lowest third of the small intestine. They occasionally appeared, however, in small numbers in both the duodenum and colon. The larger and to all appearances older nodules were found in the ileum near the cæca.

"In the badly affected portion the nodules gave the appearance of closely set protuberances, varying in size from barely perceptible areas of elevation to bodies 4 mm. ($\frac{1}{6}$ inch) in diameter. In some instances they appeared to overlap one another. When separated by a band of normal tissue they were round or somewhat lenticular in form. In the latter case the long diameter

* Mém. Soc. Zool. France, iv. 1891, p. 420.

† Centrbl. Bakter. iii. 1888, p. 172.

‡ B. H. Ransom, 'Manson's Eye Worm of Chicken, &c.,' Bureau of Animal Industry, U.S.A., Bulletin 60, 1904.

§ D. E. Salmon, 'Tapeworms of Poultry,' Bureau of Animal Industry, U.S.A., Bulletin 12, 1896.

‖ V. A. Moore, Bureau of Animal Industry, U.S.A., Circular III., 1895.

was usually transverse to the long axis of the intestine. The larger nodules were of a pale dark-yellowish colour, while the smaller ones varied in shade from the more highly coloured areas to the neutral grey of the normal serosa. To the touch they gave the sensation that would be expected if the subserous and muscular coats were closely studded with small, oval, solid bodies. The mucosa presented similar elevations. Attached to the mucosa over the nodules were a number of tapeworms. There were also in the more advanced cases a variable number of small (0·5 to 1 mm.) areas over the larger nodules in which the mucosa had sloughed, leaving small ulcerated depressions.

"The larger nodules contained a greenish-yellow necrotic substance, which appeared in the advanced stages as a sequestrum with a roughened surface. On section it has a glistening, homogeneous appearance. Surrounding the necrotic substance was a thin layer of infiltrated tissue. The smaller nodules contained a more purulent-like substance and the smallest appeared to the naked eye as areas of infiltration. Sections of the affected intestine showed upon microscopic examination that the heads of the tape-worms had penetrated the mucous membrane and were situated in different layers of the intestinal wall (*cf.* Pl. LX. fig. 17). They were frequently observed between villi. As would be expected, the heads were not readily detected in the necrotic masses contained in the larger nodules, but were almost invariably seen in the smaller ones. In a few sections the tape-worm could be traced through the mucosa to the nodule in the muscular tissue in which its head appeared. In the earlier stage of the nodular development there is a cell infiltration about the head of the worm. This process continues until the infiltrated tissue reaches a considerable size.

"The worms attached to the mucosa were usually small. A larger form was commonly found in the intestinal contents. Although macroscopically they appeared to be different, Doctor Stiles found that they were presumably of the same species.

"*Economic Importance.*—The importance of this disease is much greater than it at first appears, as the close resemblance of the nodules to those of tuberculosis renders it of much significance from a differential standpoint. As the intestines are stated to be frequently the seat of the specific lesions of tuberculosis in fowls, it is of the greatest importance that a thorough examination be made before a positive diagnosis is pronounced. There are already several statements concerning the presence of tuberculosis in fowls in which the data given are not sufficient to differentiate the disease from the one here described. A somewhat analogous disease of sheep caused by a nematode (*Œsophagostoma columbianum* Curtice) has led to the deliberate destruction of many animals, the owners believing that tuberculosis was being eliminated from their flocks.

"As the inquiry into the cause of poultry diseases becomes more general it is probable that this affection will be occasionally encountered, and unless its nature is recognized it may in some instances, like the sheep disease, lead to an unwarranted destruction of property.

"In addition to its importance in differentiating tuberculosis it is in itself a malady worthy of careful attention. The fact that it has already appeared in two flocks in the District of Columbia, and also in the States of North Carolina and Virginia, shows that the infesting cestode is quite widely distributed in this country. It is highly probable that the total loss it occasions, both from deaths and from the shrinkage of poultry products, due to the chronic course of the disease it produces, is very large."

(ii.) Davainea cesticillus (Molin), 1858.

Synonym: *Tænia cesticillus* (Molin).

This is a small species; the majority of our specimens measured between 5·5 and 9 mm. in length. Few were longer, though many were shorter. They were all young immature specimens. The broadest at their broadest part, usually about the level of the last proglottis but two or three, measured 1 mm. across. They tapered to the last proglottis, which averaged about 0·5 mm. in diameter, and still more do they taper towards the head, where the narrow neck is but 0·2 mm. The head itself is 0·3 to 0·5 mm. across and perhaps two-thirds of this in length.

The hooks in the rostellum were numerous, I should judge a few hundred, but I could not, on account of their minute size, count accurately: they measured about 7 μ in length.

The head when the rostellum is withdrawn is somewhat cup-shaped and the four suckers are on the edge of the cup, opening at the edge and slightly inwards. There is practically no "neck," just a constriction between the head and the first proglottis. Behind the head the proglottides increase markedly in size, and the third proglottis in most specimens is already as broad as the head. They are deeply imbricated and the overlapping edge is full and rounded. At the level of the anterior end of each proglottis is a constriction which slightly separates off the overlapping lobe from the preceding proglottis, to which it, of course, belongs. This gives a somewhat ear-like outline to the side of each segment. The constriction first appears in about the tenth proglottis, and the characteristic outline is lost in the last, where the overlapping edges curve in as if to guard the excretory opening. The total number of the proglottides varies a little with the variable length, but differences in length depended far more on the state of contraction of the body than on the number of segments. Roughly speaking, the numbers varied from about eighteen to about twenty-eight proglottides.

The genital pore is alternate and fairly regularly so; the penis often projects, and then it is apparent that the pore lies rather anteriorly and is all but overlapped by the imbricated edges of the proglottis next in front.

Sections show that there are a number of calcareous bodies in the tissues; some of these are in optical section brick-shaped, and others spherical or shaped like a cottage-loaf. These latter are bigger than the others and show numerous radiating lines. Posteriorly the tissue becomes very highly vacuolated and the embryos lie in small packets which do not seem to be in a uterus, and may be, as Morell suggests in *D. urogalli*, in the lumen of the ovary itself.

This tape-worm, common in chickens and turkeys, is only an occasional parasite of the grouse, and has in many hundreds of birds we have examined only been found twice, and in neither case has its presence been associated with any lesions. As a factor in grouse-disease it may be neglected. In both cases only young, immature, not fully grown specimens were met with. Its second host is according to Railliet, quoting Grassi and Rovelli, probably some Coleopteran or Lepidopteran, but at present this has not been proved.

Hymenolepis Weinland, 1858.

(iii.) Hymenolepis microps (Diesing), 1850.

Synonyms: *Tænia microps* (Diesing), 1850.
Hymenolepis tetraonis (Wolffh.), 1900 *.

This is an extremely delicate, transparent tape-worm which exists in almost countless numbers in the duodenum of *Lagopus scoticus*. It is also recorded from the Blackcock and the Capercaillie. On cutting open the duodenum of a grouse infested with these worms—and we have rarely found a bird free from them except in the winter months—they are not at first apparent. They are so fine and so transparent that they are practically invisible when alive, and the contents of this part of the alimentary canal appears very much like a thick purée. If we add to this some fixing agent such as corrosive sublimate this purée resolves itself into a mass of very fine, delicate, white threads inextricably tangled up together and so numerous that there seems but little room left in the duodenum for the passage of the food (Pl. LVIII. fig. 3). If, with great care—for they break at the slightest strain—we succeed in disentangling one of these worms we shall find its head embedded to a greater or less extent in the mucous lining of the duodenum, into which, to use a poetic phrase, "it nuzzles" whilst the body of the worm floats freely in the fluid contents of this part of the alimentary canal. If we also succeed in freeing the head we now have a complete worm and can study its structure.

* Wolffhügel, K., "Beitrag zur Kenntniss der Vogelhelminthen," Inaug.-Diss., Freiburg-i.-B. 1900.

Before giving some anatomical details of *H. microps* it is worth mentioning that Wolffhügel found fragments of this species—none with the head—in the small intestine, large intestine, and end—he does not say which end—of the cæca of *Tetrao urogallus*. We have also found short chains of ripe proglottides passing down the alimentary canal on their way to the exterior, but the tape-worm as an individual lives only in the duodenum.

H. microps is a very long worm, attaining in the longest examples a length of some 15–16 cms. It consists of an enormous number of proglottides. The first two millimetres which come after the head contain as many as 60–70 segments, and lower down the body, where the proglottides were mature, as many as 10 proglottides measured but 1 mm. Of course these measurements depend entirely on the state of the contraction of the worm, but if we take the mean between them as a rough average approximation we shall get the astonishing number of 3000 proglottides in a single specimen. As each proglottis contains a large number of eggs and as they are being continually renewed, and as, further, the number of tape-worms in the duodenum amounts to hundreds, it is easy to see that a grouse-moor must be just peppered over with ova (Pl. LVII. fig. 4).

The head is somewhat squarish (Pl. LX. fig. 18), with a central retractile rostellum and four suckers at the corners. The rostellum is surrounded by a closely packed ring of very numerous spines or hooks (Pl. LX. figs. 19 & 20). These are very minute and, except in the fresh specimen, very difficult to see, and even then it requires an immersion-lens to make out anything of their structure. Their proximal end is rounded, and then comes a constriction ; the spine then thickens till about the middle of its length and then tapers to a very fine point. Although these spines are slightly curved, they are in no sense hooked (Pl. LX. fig. 20). I have tried to measure the length of these spines from specimens of the head, which has been cut in sections. I am not quite sure that the hooks were entire, and so am not quite sure that my measurement is large enough, but I should put their length at about 16 μ—certainly not less. The hooks seem to be in a single row, but very close together.

The suckers are deep and well marked, but it must always be borne in mind how very small the head is, and corresponding with this the suckers are also very minute.

The posterior edge of each proglottis is "sailliant," but it does not overhang the succeeding proglottis; it stands out like the tooth of a saw, and viewed laterally the side of this worm is very saw-like. Throughout the body the proglottides are much broader than they are long. In the older ones there are numerous calcareous bodies, the measurements of which Wolffhügel gives as 0·018 mm. by 0·01 mm. (Pl. LX. fig. 21).

The genital pore is in all the segments on the same side; the left, judging by the orientation suggested by the female reproductive organs, being on the ventral surface. The vagina opens

into a peculiarly large and muscular receptaculum seminis, which runs across the proglottis and then turns backward; in some preparations this turn is seen "en face" and then the radiating muscles give the appearance of a ring of very fine spines, and, indeed, at first I thought that there was such a ring, but I believe the above is the true explanation. There are three testes the vasa deferentia of which unite and after entering the cirrus-bulb enlarge to form a vesicula seminalis. The vagina opens ventral to the penis. The uterus is a single chamber unbranched. It forms a conspicuous feature in the hinder end of stained specimens. At first it appears as a spherical organ lying in the middle line at the hinder end of each proglottis, but as it grows and absorbs more of the parenchyma it tends to become triangular or square, but always with very rounded angles. It contains a large number of relatively large onchospheres or tape-worm embryos (Pl. LX. fig. 22). According to Wolffhügel, the embryos measure 0·02 mm. in breadth by 0·04 mm. in length. The typical six embryonic hooks are very characteristic. The partners in each pair, for instance, are usually widely divaricated; their length is 0·014 mm. These characteristic *Hymenolepis* ova have three envelopes: the innermost, closely applied to the embryo, is never produced into horns; between it and the middle envelope is only a clear fluid in which the embryo floats; between the middle and the outer envelope are the much vacuolated remains of cells. The position of the embryo is eccentric with regard to this outer shell (Pl. LX. fig. 22), which measures 0·073 mm. by 0·066 mm. The measurements are again Wolffhügel's. The characteristic hooks are figured on Pl. LX. fig. 23.

We have no information about the fate of these embryos, but as a general rule the cystic form of this genus lives in some Insect or Myriapod, as is shown by the fact that this genus of tape-worm occurs in Bats, Insectivores, Rodents, and Insectivorous birds. *Hymenolepis nana* occurs in man, most frequently in children, and is not at all uncommon in Italy. Sporadic cases of *H. diminuta* occurring in man are also recorded.

We have made and we are making laborious investigations to try and discover this second host. In searching for the cysts of the Tape-worms we began with the insects which occurred most commonly in the crop of the grouse. These we examined microscopically, both after teasing the body up in glycerine and by grinding it up—but not too finely—in a pestle; in some cases also, as Mr. Fryer* has recorded, sections were made and examined, but always without result.

We were at two disadvantages in hunting for the cysts: firstly, we did not know what the cysts of either *Davainea urogalli* or *Hymenolepis microps* were like; and, secondly, the tissues

* Interim Report of the Grouse Disease Inquiry.

of the insects and spiders which we examined are little, if at all, known, and more than once we have at first sight taken some organ proper to the insect for a cestode cyst, only to our great disappointment to discover later that we were looking at an ovum or other structure belonging to the putative host.

During some days Dr. Wilson and I spent in Edinburgh towards the end of July, 1908, we examined a considerable number of the commoner insects found on the moors in the hope of throwing some light upon the life-history of the tape-worms so common in the grouse. The specimens we investigated were collected by Mr. P. H. Grimshaw, who is preparing a Report on the Insects of the Moors. We are greatly indebted to him and to the Keeper of the Museum, Mr. W. Eagle Clarke, and to Mr. J. Ritchie for kindly placing at our disposal a work-room and other accommodation which greatly facilitated our work. When the insect had not been specifically named we always kept a similar specimen for subsequent identification in case it should contain the cyst; but, alas! here again our labour was in vain.

In the manner indicated we examined the following Insects, in every case looking through the débris of some four or five specimens.

Diptera.

(i.) *Monophilus ater*, one of the subfamily Limnobiinæ of the Tipulidæ. A very common constituent of the food of young grouse. No trace of a cyst was found, but in one specimen an immature nematode was wriggling about.

(ii.) *Bibio* sp. Here again we drew a blank.

(iii.) *Cyrtoma spuria*, one of the Empidæ. This fly is small and seemed to have little interior; no trace of a cyst was found. In another small Empid fly we discovered a Gregarine.

(iv.) *Scatophaga* sp. *Scatophaga stercoraria* is perhaps the commonest fly in Scotland, and, owing to the larva living in the droppings of the grouse, it can hardly fail to contain the eggs of the cestodes; but we have never found a *Scatophaga* in the crop of a grouse, and there is some reason to doubt if the tape-worm eggs develop in this fly. After searching for a long time through the tissues of many specimens of *Scatophaga*, we only managed to find one ovum, apparently of *Davainea urogalli*, and that was no further advanced than when it was laid.

Plecoptera.

Similar gropings through the disjected membranes of an unknown species of Perlid produced no better results.

Arachnida.

We also investigated the tissues of a spider very common on the moors, and of a phalangid, with an equal want of success.

NOTE BY WM. BYGRAVE, M.A., ON THE SEARCH FOR CYSTS.

Since September 1908 I have been making a series of investigations in connexion with the Grouse-Disease Inquiry. My work has consisted of a careful examination of the tissues of certain insects found on Grouse-moors in various parts of England and Scotland, the object being to discover, if possible, cysts of the three species of tapeworm which infest the grouse, viz. :—

Davainea urogalli (Modeer, 1790).
Davainea cesticillus (Molin, 1858).
Hymenolepis microps (Diesing, 1850).

The insects examined to date are specimens of *Scatophaga squalida* from Ballindalloch, and *S. stercoraria* from Burley, Dunachton, and Forrigen.

The specimens were sent to me by Mr. P. H. Grimshaw, from the Royal Scottish Museum, Edinburgh, preserved in spirit.

The method of examination was as follows :—

The legs and head were removed and the body of the insect teased up in 70 per cent. alcohol as finely as possible with needles, the legs and head being firstly teased and then gently pounded in a mortar.

The material thus obtained was examined under a cover-glass, a mechanical stage being used to ensure that none of the material was overlooked. The powers used were Leitz Obj. $\frac{1}{4}''$ and $\frac{1}{6}''$ Oc. 2 and 4; an oil immersion-lens being used in cases of doubt. So far the examination has yielded no results. Nothing has been found which in any way resembled the cysts, one or two of which have been figured, of species allied to the three tape-worms mentioned above.

EXPLANATION OF THE PLATES.

PLATE LVI.

Fig. 1. View of a portion of the small intestine of the grouse well infested with *Davainea urogalli* (Modeer) and cut open to show the worms.

PLATE LVII.

Fig. 2. A single specimen of *D. urogalli*, isolated to show the attenuated head.
4. A single specimen of *Hymenolepis microps*, isolated.
(The figures 2 and 4 are very slightly magnified.)

PLATE LVIII.

Fig. 3. View of a portion of the duodenum of the grouse, well infested with *Hymenolepis microps* (Diesing), cut open to show the worms.

PLATE LIX.

Fig. 5. Head of *D. urogalli* with proboscis half-exserted and armed suckers.
6. The same, with the proboscis completely retracted. This specimen shows the calcareous bodies well.
7. Portion of the double circle of hooks from the proboscis of *D. urogalli*.
8. Isolated hooks from the same, showing slight modification in outlines.
9. Portion of the ring of hooks which surrounds one of the suckers of *D. urogalli*, showing the irregular arrangement of the hooks.
10. Isolated hooks from the same, showing slight modification in outline.

Fig. 11. Magnified view of mature proglottis of *D. urogalli*. *gp.*, genital pore; *ov.*, ovary: *p.*, penis; *t.*, testes; *v.*, vagina: *vit.*, vitellarium; *w.v.*, excretory system.
12. Ova of *D. urogalli*, showing the ovum and yolk-vesicles.
13. Longitudinal horizontal section through the same, showing the great extension of the excretory transverse canals, and the ova scattered in egg-capsules.

PLATE LX.

Fig. 14. A similar section through the last proglottis, showing the enormous transverse canal at the level of the breaking zone and the excretory pore *e.p.*
15. Ova of *D. urogalli* more advanced than those shown in fig. 12, showing the onchosphere and traces of the yolk-vesicles.
16. An isolated hook from the same.
17. Transverse section of the walls of intestine of a fowl, showing *Tænia botriopliti* embedded in the deeper layers of the intestinal wall. *aa.*, intestinal mucosa; *b.*, muscular layers; *sp.*, peritoneal lining; *tt.*, anterior ends of the tape-worms; *e.*, mass of exudate produced by the irritation of the head of the Tænia. (From Piana, Mem. Ac. Sci. Istit. Bologna, series 4, vol. ii. 1880, p. 387.)
18. Head of *Hymenolepis microps* (Diesing), highly magnified.
19. Section through the retracted proboscis of the same, highly magnified to show the arrangement of the hooks.
20. Isolated hooks of the same seen under $\frac{1}{12}$ oil immersion-lens.
21. A few mature proglottides of the same, taken from about the middle of the body.
22. Onchospheres of *H. microps* in the characteristic three envelopes.
23. Hooks from the same.

4. Internal Parasites of Birds allied to the Grouse. By A. E. SHIPLEY, M.A., Hon. D.Sc., F.R.S., F.Z.S., Fellow and Tutor of Christ's College, Cambridge, and Reader in Zoology in the University.

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The following is a brief enumeration of the Cestode, Trematode, and Nematode parasites of the Grouse, the Ptarmigan, the Blackcock, and the Capercaillie. To these I have added the Willow-grouse and the Hazel-hen, although these birds, unlike the three former, are not denizens of the British Isles. It will be noticed that but two Nematodes, *Trichosoma longicolle* (Rud.) and *Heterakis papillosa* (Bloch), and two Cestodes, *Davainea urogalli* and *Hymenolepis microps*, are common to our grouse and to its allies. The first named round worm and the tape-worm are found in all three, Blackcock, Capercaillie, and Grouse, and in none of the other nearly allied birds; whilst *Heterakis papillosa* has been recorded from the Ptarmigan, the Capercaillie, the Hazel-hen and the Grouse, besides from many other birds.

Heterakis perspicillum (Rud.) also occurs in three hosts, in the Blackcock, the Hazel-hen, and the Capercaillie. All the other Nematode parasites mentioned occur in a single host, except *Heterakis compar* (Schrank) which is found in both the Ptarmigan and the Capercaillie. Of the Cestodes, *Davainea urogalli* and *Hymenolepis microps* occur in the Grouse, the Blackgame, and the Capercaillie.